

I claim:

1. A method of filtering an input data stream  $D_{in}$  with a digital filter that defines a quantized impulse response to thereby generate filtered output signals of a filtered output data stream  $D_{out}$  wherein said input data stream  $D_{in}$  has data samples that occur at a system rate  $F_s$ ,

5 the method comprising the steps of:

converting successive strings of  $M$  successive data elements in said input data stream  $D_{in}$  to  $M$  parallel data elements that respectively occur at a substream rate  $F_s/M$  in  $M$  data substreams  $D_{sbstrm}$ ; and

10 at said substream rate  $F_s/M$ , generating  $M$  convolutions of said quantized impulse response with said  $M$  data substreams wherein each of said convolutions is arranged to generate a different one of  $M$  successive filtered output signals.

2. The method of claim 1, wherein said converting step includes the steps of:

5 delaying said input data stream  $D_{in}$  by at least one delay of  $1/F_s$  to generate at least one delayed version of said input data stream  $D_{in}$ ; and

at said substream rate  $F_s/M$ , providing corresponding data elements of said input data stream  $D_{in}$  and said delayed version.

3. The method of claim 2, wherein said delaying step includes the step of passing said input data stream  $D_{in}$  through at least one data register.

4. The method of claim 2, wherein said providing step includes the step of latching said data elements at said substream rate  $F_s/M$ .

5. The method of claim 1, wherein said convolution generating step includes the steps of:

at said substream rate  $F_s/M$ , performing the steps of:

a) delaying each of said  $M$  parallel data elements with

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5 delays of  $MF_s$  to generate a plurality of respective delayed data elements;

b) multiplying said delayed data elements and at least one selected parallel data element by selected coefficients of said quantized impulse response;

10 and

c) summing products generated in said multiplying step; in said multiplying step, choosing said selected parallel data element and said selected coefficients to generate one of said M successive filtered output signals;

15 and

executing M variants of said performing and choosing steps to generate all of said M successive filtered output signals.

6. The method of claim 1, wherein said convolution generating step includes the steps of:

at said substream rate  $F_s/M$ , delaying each of said  $M$  parallel data elements with delays of  $M/F_s$  to generate a plurality of respective delayed data elements;

at said substream rate  $F_s/M$ , performing the steps of:

a) multiplying said delayed data elements and at least one selected parallel data element by selected coefficients of said quantized impulse response;

10 and

b) summing products generated in said multiplying step; in said multiplying step, choosing said selected parallel data element and said selected coefficients to generate one of said M successive filtered output signals;

15 and

executing M variants of said performing and choosing steps to generate all of said M successive filtered output signals.

7. The method of claim 1, further including the step of selecting, at said system rate  $F_s$ , said M filtered output signals in successive order to thereby form said filtered output data stream  $D_{out}$ .

8. The method of claim 1, wherein said selecting step includes the step of multiplexing said M successive filtered output signals.

9. The method of claim 1, wherein M is two.

10. The method of claim 1, wherein M is at least three.

11. A digital filter that has a quantized impulse response and that filters an input data stream  $D_{in}$  to thereby generate filtered output signals of a filtered output data stream  $D_{out}$  wherein said input data stream  $D_{in}$  has data samples that occur at a system rate  $F_s$ , the filter comprising;

5 a converter that converts successive strings of M successive data elements in said input data stream  $D_{in}$  to M parallel data elements that respectively occur at a substream rate  $F_s/M$  in M data substreams  $D_{sbstrm}$ ; and

10 a data processor that performs the step of generating, at said substream rate  $F_s/M$ , M convolutions of said quantized impulse response with said M data substreams wherein each of said convolutions is arranged to generate a different one of M successive filtered output signals.

12. The filter of claim 11, wherein said converter is an M-stage buffer store.

13. The filter of claim 11, wherein said converter includes:  
at least one register that realizes at least one delay of 1/ $F_s$  to generate at least one delayed version of said input data stream  $D_{in}$ ; and  
5 latches that provide corresponding data elements of said input data stream  $D_{in}$  and said delayed version.

14. The filter of claim 11, wherein said convolution generating step includes the steps of:

at said substream rate  $F_s/M$ , performing the steps of:  
a) delaying each of said M parallel data elements with

15. The filter of claim 11, wherein said convolution generating step includes the steps of:

at said substream rate  $F_s/M$ , delaying each of said  $M$  parallel data elements with delays of  $M/F_s$  to generate a plurality of respective delayed data elements;

at said substream rate  $F_s/M$ , performing the steps of:

- a) multiplying said delayed data elements and at least one selected parallel data element by selected coefficients of said quantized impulse response;

10 and

b) summing products generated in said multiplying step; multiplying step, choosing said selected parallel data item and said selected coefficients to generate one of said successive filtered output signals;

15 and

executing M variants of said performing and choosing steps to generate all of said M successive filtered output signals.

16. The filter of claim 11, further including a multiplexer that selects, at said system rate  $F_s$ , said  $M$  filtered output signals in successive order to thereby form said filtered output data stream  $D_{out}$ .

17. The filter of claim 11, wherein M is two.

18. The filter of claim 11, wherein M is at least three.

19. The filter of claim 11, wherein said data processor includes at least one programmable signal path that is programmed to execute at least one of the M convolutions of said generating step.

20. The filter of claim 11, wherein said data processor includes M fixed signal paths that are each arranged to execute a respective one of the M convolutions of said generating step.

21. A digital filter that has a quantized impulse response and that filters an input data stream  $D_{in}$  to thereby generate filtered output signals of a filtered output data stream  $D_{out}$  wherein said input data stream  $D_{in}$  has data samples that occur at a system rate  $F_s$ , the filter comprising;

5 a converter that converts successive strings of M successive data elements in said input data stream  $D_{in}$  to M parallel data elements that respectively occur at a substream rate  $F_s/M$  in M data substreams  $D_{sbstrm}$ ; and

10 M convolvers which generate, at said substream rate  $F_s/M$ , M convolutions of said quantized impulse response with said M data substreams wherein each of said convolvers is arranged to generate a different one of M successive filtered output signals.

22. The filter of claim 21, wherein each of said convolvers includes: delay structures that delay said M parallel data elements with delays of  $M/F_s$  to generate a plurality of delayed data elements;

5 multipliers that each multiply a selected one of said parallel data elements and said delayed data elements by selected coefficients of said quantized impulse response; and

10 summers that sum products generated in said multipliers; wherein said selected parallel data elements and said selected coefficients are chosen in each of said convolvers to generate a respective one of said M filtered output signals.

23. The filter of claim 21, wherein said convolvers include a set of delay structures that delay said  $M$  parallel data elements with delays of  $M/F_s$  to generate a plurality of delayed data elements and each of said convolvers further includes:

5        multipliers that each multiply a selected one of said parallel data elements and said delayed data elements by selected coefficients of said quantized impulse response; and  
summers that sum products generated in said multipliers;  
wherein said selected parallel data element and said selected  
10      coefficients are chosen in each of said convolvers to generate a respective one of said  $M$  filtered output signals.

24. The filter of claim 21, further including a multiplexer that selects, at said system rate  $F_s$ , said  $M$  filtered output signals in successive order to thereby form said filtered output data stream  $D_{out}$ .

25. The filter of claim 21, wherein  $M$  is two.

26. The filter of claim 21, wherein  $M$  is at least three.